Using
Ocean Optics Spectrometers
with the
PASCO Xplorer GLX

Introduction

This manual contains instructions for using an Ocean Optics spectrometer with the PASCO Xplorer GLX handheld datalogger. The combination of these two devices can be used to monitor and record a spectrum or to continuously record light intensity in a defined wavelength band. You can use the spectrometer to analyze light from sources such as the sun or a fluorescent lamp, or you can use it with the Integrated Light Source and Cuvette Holder to analyze light transmitted through a solution. In addition to light intensity, the GLX calculates absorbance, transmission and relative irradiance.

These instructions assume that you are familiar with the general operation of the Xplorer GLX. For complete instructions on using the GLX, see the Xplorer GLX Users' Guide (PASCO manual number 012-08950).

Compatible Spectrometer Models

The following spectrometers manufactured by Ocean Optics are compatible with the Xplorer GLX (license key required):

- USB650 Red Tide
- USB2000
- USB4000
- HR4000

Important Note

An Ocean Optics spectrometer in some ways resembles other sensors used with the GLX; however, there are some important differences:

- The GLX requires a special license to work with an Ocean Optics spectrometer. When you purchase a license, you receive a USB flash drive that will install a license key on your GLX. A single flash drive may contain more than one license key for licensing multiple GLXs.
- To collect data from a spectrometer, the GLX must be in standalone mode (not connected to a computer). Once you have recorded data, you can analyze them on the GLX or transfer them to your computer.
- A spectrometer can not be used simultaneously with other sensors.

Setting Up the Spectrometer and GLX

A. Update the GLX

Important note: *If your GLX has firmware version lower than 1.3, upgrade the firmware before you install the license key.*

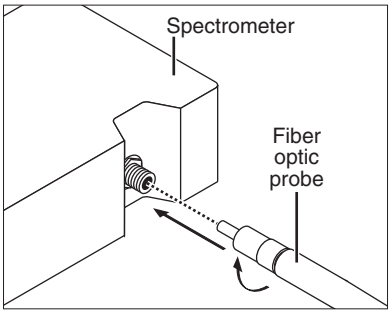
Check the firmware version number at the bottom of the splash screen that appears briefly when you turn on your GLX. If it is lower than 1.4, follow these steps:

1. Visit www.pasco.com/glx
2. Follow the instructions on that web page to download and install the latest GLX firmware.

You can also update the GLX by connecting it to any computer that has DataStudio version 1.8 (or later) installed on it.

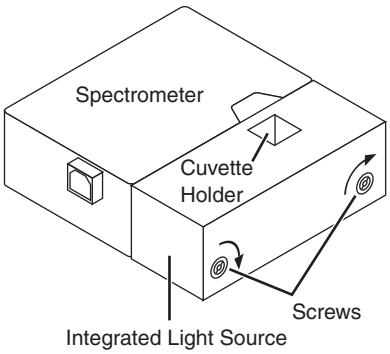
B. Install the License Key

Important note: *The license key is removed from the flash drive when it is copied to the GLX. A single license key can not be moved from one GLX to another or installed on more than one GLX. After the license key is installed, it will reside on your GLX permanently.*



1. If the GLX is connected to a computer, disconnect it.
2. Plug the license key flash drive in the GLX's USB port.
3. On the GLX screen, you will see a message such as: “There is 1 license available for 'Ocean Optics Spectrometer'. Would you like to add a license to this GLX?” Press F1 for Yes.
4. You will see a message such as: “Successfully added license for Ocean Optics Spectrometer.” Press F1 for OK.

C. Connect Optional Hardware

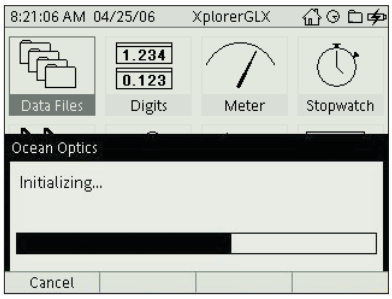


- If you plan to use a fiber optic probe, insert one end of the probe into the spectrometer's light input connector and turn the threaded collar on the probe to secure it to the spectrometer.
- If you plan to use the Integrated Light Source and Cuvette Holder, align it with the spectrometer, press the connectors together, and tighten the captured screws.

D. Connect the Spectrometer to the GLX

1. Turn on the GLX.
2. Use the cable (included with the spectrometer) to connect the USB port of the spectrometer to the USB port of the GLX.

After a few seconds, you will see the Initializing screen, then the Spectrometer Analysis Configuration screen.



Initializing screen
(appears a few seconds after connecting the spectrometer)

E. Configure the Spectrometer

In the Spectrometer Analysis Configuration screen, follow these general steps. (For a detailed explanation of the parameters in the configuration screen and how to change them, see pages 3–6.)

1. Set the parameters in the **Data Acquisition** tab as desired.

2. *(This step is not always necessary.)* Go to the **Lamp** tab and change the parameters there if necessary.

3. *(Do this step if you plan to use Time Acquisition or Beer's Law mode or the* Minus Dark, Absorbance, Transmittance, or Relative Irradiance mea*surements.)*

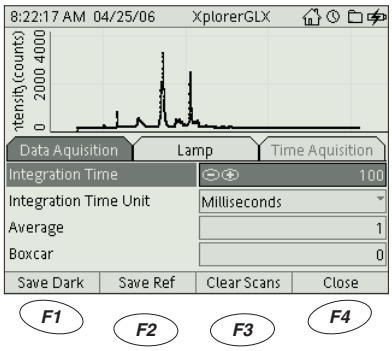
   a. Turn off the light source or block light from entering the spectrometer. Press F1 to save the dark scan.

   b. Allow "reference light" to enter the spectrometer. Press F2 to save a reference scan.[1]

4. *(Do this step only if you plan to use Time Acquisition or Beer's Law mode.)* Go to the Time Acquisition tab. Set the scan mode and other parameters as desired. (See page 6 for more information.)

5. After you have finished setting spectrometer parameters and options, press F4 to close the configuration screen.

See page 6 for instructions on recording and viewing data.



Spectrometer Analysis Configuration screen
(appears after the Initializing screen)

[1]What you use as the "reference light" depends on what you plan to measure. See see "F2 Save Ref" on page 4 for details.

Spectrometer Analysis Configuration Screen

The Spectrometer Analysis Configuration screen is where you set the parameters that control how the spectrometer and GLX collect and process data.

To Open the Configuration Screen

- **If the spectrometer is not yet connected:**

  Connect the spectrometer to the GLX's USB port and wait for the configuration screen to open automatically.

- **If the spectrometer is already connected:**

  1. Press ⌂ + F1 to open the Graph screen (if it is not already open).

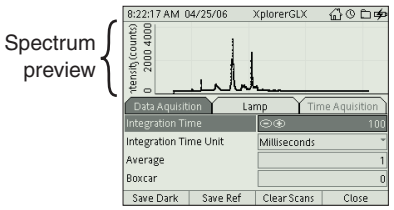
  2. Press F3 to open the **Tools** menu.

  3. Use the arrow keys to highlight **Spectrum Analysis Config.**

  4. Press ✓.

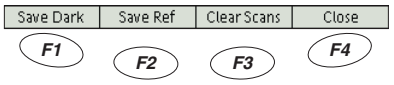
Spectrum Preview

When the configuration screen opens, the GLX automatically starts monitoring and displaying spectrum data in the upper half of the screen. With this preview, you can immediately see the effect of changes that you make to parameters. Press ▶ to manually stop or re-start spectrum monitoring.



Function Keys

Use the function keys to save and clear dark and reference scans and to close the configuration screen.



Function keys

F1 Save Dark With the light source off or blocked (so that no light enters the spectrometer), press F1 to save the dark scan.

F2 Save Ref With "reference light" entering the spectrometer, press F2 to save the reference scan. Do this *after* setting the parameters in the Data Acquisition tab (see "Data Acquisition Tab" below).

Your "reference light" may be one of the follow (depending on what type of measurement you plan to make):

- The Integrated Light Source with a reference cuvette[2] in place (for measuring absorbance and transmission of light through a solution).
- A lamp with a known color temperature (for measuring the relative irradiance of light sources).
- Any light source (if you plan to use *only* the Intensity and Minus Dark measurements).

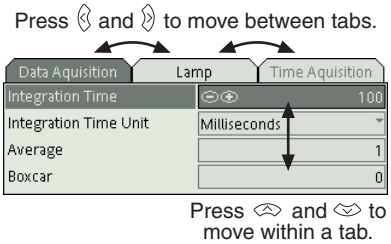
[2]A reference cuvette represents 100% transmission.

F3 Clear Scan Press F3 to delete the dark and reference scans.

F4 Close Press F4 to close the configuration screen.

Navigating in the Configuration Screen

The configuration parameters and options are contained in three tabs: **Data Acquisition**, **Lamp**, and **Time Acquisition**.



To navigate between the tabs, press the left and right arrow keys. (Note that the **Time Acquisition** tab will not be available until you have saved dark and reference scans.)

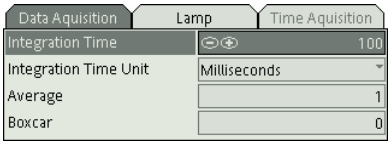
Navigate within a tab by pressing the up and down arrow keys to highlight different parameter and options. To change the highlighted parameter or option, do one of the following:

- Press + or − to change the value of the parameter by 1.
- Press ✓ to make the parameter editable. Type the desired value. Press ✓ again.
- Press ✓ to toggle a two-choice option.

or

- Press ✓ to open a pop-up menu. Use the arrow keys to highlight the desired menu option. Press ✓ again.

Data Acquisition Tab



Data Acquisition tab

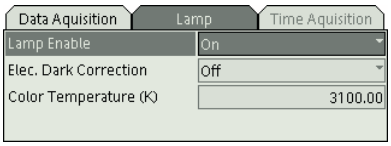
Integration Time Integration time is analogous to the shutter speed of a camera. The higher the integration time, the longer the detector monitors incoming light. Adjust the integration time so that the greatest amount of light that you anticipate for your application causes a signal of about 85% of the spectrometer's capability (3500 counts out of 4096 counts maximum, for example).

Integration Time Units Use this option to specify whether the integration time above is expressed in milliseconds or microseconds.

Average This parameter specifies the number of discrete spectral acquisitions that the GLX collects and averages before displaying or recording a spectrum. The higher the value, the better the signal-to-noise ratio (S:N). The S:N will improve by the square root of the number of scans averaged.

Boxcar This parameter sets the boxcar smoothing width. Boxcar smoothing averages groups of adjacent pixels. For example, if the value is 5, the GLX averages each pixel with 5 pixels to its left and 5 pixels to its right (a total of 11 pixels). The greater this value, the smoother the data and the higher the S:N. If the value is too high, a loss in spectral resolution will result. The S:N will improve by the square root of the number of pixels averaged.

Lamp Tab



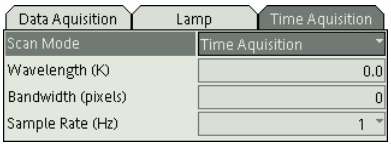
Lamp tab

Lamp Enable If you have the Integrated Light Source connected to your spectrometer, use this option to turn it on and off. It is on by default.

Elec. Dark Correction This option enables or disables the correction of the spectral data for the electrical dark signal. The effect is to shift the entire spectrum vertically so it reads close to zero counts in the absence of light.

Color Temperature (K) If you know the color temperature of the lamp that you are using for the reference scan, enter it here in units of kelvins. The GLX uses this value to calculate relative irradiance. (If you do not plan to use the relative irradiance measurement, the value of this parameter does not matter.)

Time Acquisition Tab



Time Acquisition tab

Note: To enter this tab, you must have saved dark and reference scans.

Scan Mode There are three choices: *Scope* (or "Spectral Scope"), *Time Acquisition*, and *Beer's Law*. See "Collecting Data" below for descriptions of these modes. The other three parameters in this tab affect Time Acquisition and Beer's Law modes only.

Wavelength This parameter specifies the wavelength (in nm) to be monitored.

Bandwidth Use this parameter to set the wavelength range to be monitored. The value of **Bandwidth** is equal to the number of pixels on

either side of the pixel specified by the **Wavelength** parameter. Therefore, the total number of pixels equals **Bandwidth** × 2 + 1.

Sample Rate This parameter specifies the rate (in Hz or samples per second) at which the GLX will record data.

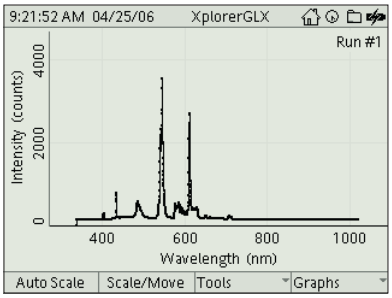
Collecting Data

View and record data using Spectral Scope mode, Time Acquisition mode, or Beer's Law mode as described below.

Spectral Scope Mode

Collect data in Spectral Scope mode when you want to monitor or record the whole spectrum. Each recorded spectrum represents light collected over a period of time determined by the **Integration Time** and **Average** parameters (see pages 5 and 5).

Note: Spectral Scope scan mode is not the same as the regular GLX scope mode used with other sensors.



Spectral Scope mode

Spectral Scope is the default mode. If you have switched to a different mode, go to the Time Acquisition tab of the configuration screen (see above) to switch back.

To monitor and record data in Spectral Scope mode:

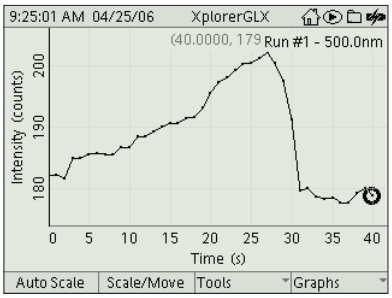
1. If the configuration screen is open, press F4 to close it.
2. While viewing the Graph display, press ▶ to begin monitoring data. A periodically updated spectrum appears on the display, and the clock icon (🕒) appears in the upper right corner of the screen.

Note: While viewing spectral data, you can use normal GLX Graph screen functions, such as Auto Scale (F1) and Scale/Move (F2). See the GLX Users' Guide for more information.

3. To record the spectrum, press ▶ again. The graph freezes on the most recently collected spectrum, and this spectrum is saved as a data run (named "Run #1", "Run #2", etc.)
4. Press ▶ again to start monitoring again.
5. Repeat steps 3 and 4 to record additional spectra.

Time Acquisition Mode

Use Time Acquisition mode to collect data from a single channel (either a single pixel or a block of adjacent pixels). The location and width of the block is determined by the **Wavelength** and **Bandwidth** parameters. The rate of data collection is determined by the **Sample Rate** parameter. Go to the Time Acquisition tab of the configuration screen (see page 5) to put the GLX into Time Acquisition mode and to set the parameters; then follow these steps:



Time Acquisition mode

1. If the configuration screen is open, press F4 to close it.

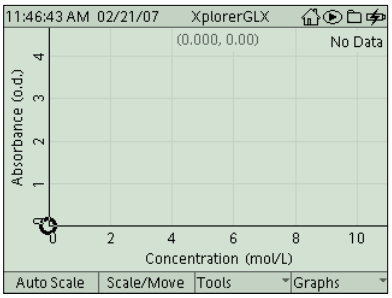
2. Press ▶ to begin recording data.

3. Press ▶ again to stop recording. The data run is saved with a name such as "Run #1 - 500.0 nm" to indicate the value of the **Wavelength** parameter.

Note: See the GLX Users' Guide for general information about collecting, displaying and analyzing data on the GLX and uploading data to a computer.

Beer's Law Mode

Use Beer's Law mode to make a graph of Absorbance versus Concentration. To use this mode, you will need an integrated light source and cuvette holder, cuvettes, and several different known concentrations of a solution. Beer's Law mode is similar to Time Acquisition mode in that data is collected from a single channel defined by the **Wavelength** and **Bandwidth** parameters. Follow the procedure on page 9 to use Beer's Law mode.



Beer's Law mode

Measurements

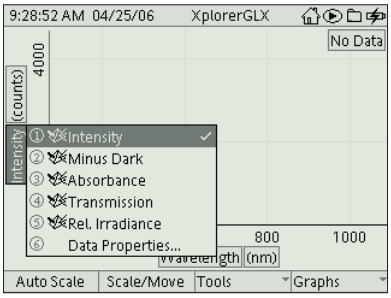
In addition to the simple Intensity measurement, the GLX records measurements derived from Intensity, the dark scan, and the reference scan. (If you have not saved dark and reference scans, the GLX will not record derived measurements.)

To select a measurement for display in the Graph screen:

1. Press ✓ to "light up" the Graph's active fields, with the "Y-axis" measurement highlighted.

2. Press ✓ again to open the menu.

3. Use the arrow keys to highlight the desired measurement and press ✓ to select it.



Graph screen menu containing measurements

The measurements are described below.

Intensity

This is the straight measurement made by the spectrometer in units of digital counts.

Minus Dark

The GLX calculates Minus Dark by subtracting the dark scan from the Intensity measurement.

Absorbance

The GLX uses this equation to evaluate each pixel on the detector and produce the absorbance spectrum:

$$A_\lambda = -\log_{10}\left(\frac{S_\lambda - D_\lambda}{R_\lambda - D_\lambda}\right)$$

Where:

S_λ = Sample intensity at wavelength λ
D_λ = Dark intensity at wavelength λ
R_λ = Reference intensity at wavelength λ (acquired with a blank cuvette in place)

Absorbance is not a valid quantity if either $(S_\lambda - D_\lambda)$ or $(R_\lambda - D_\lambda)$ is less than zero. This condition may occur if the test solution or the reference solution is very dark.

Transmission

The GLX calculates the transmission of a solution using this equation:

$$\%T_\lambda = \frac{S_\lambda - D_\lambda}{R_\lambda - D_\lambda} \times 100\%$$

Rel. Irradiance

Relative irradiance is a comparison of the fraction of energy a sample emits and the energy the spectrometer collects from a lamp with a blackbody energy distribution (normalized to 1 at the energy maximum).

To measure the relative irradiance of a sample, you must save the reference scan using a lamp of known color temperature and enter the color temperature under the Lamp tab of the configuration screen.

The GLX calculates relative irradiance with this equation:

$$I_\lambda = B_\lambda\left(\frac{S_\lambda - D_\lambda}{R_\lambda - D_\lambda}\right)$$

Where:

B_λ = Relative energy of the reference (calculated from the color temperature) at wavelength λ
S_λ = Sample intensity at wavelength λ
D_λ = Dark intensity at wavelength λ
R_λ = Reference intensity at wavelength λ

Appendix: Beer's Law Procedure

Follow these steps to obtain an absorbance versus concentration graph for aqueous solutions of copper(II) sulfate ($CuSO_4$).

Equipment

You will need the following items:

- Xplorer GLX (with Ocean Optics license key installed)
- Ocean Optics Spectrometer
- Integrated Light Source and Cuvette Holder
- Cuvettes (included with above item)
- Various aqueous solutions of $CuSO_4$ of known concentrations ranging between 0 and 0.5 M. About 3 mL of each sample needed.

Set-up

1. Turn on the GLX.

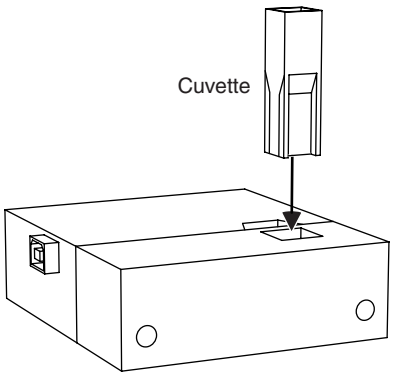
2. Connect the spectrometer to the GLX.

Result: The Initializing screen appears, followed by the Configuration screen.

3. Attach the Integrated Light Source and Cuvette Holder to the spectrometer.

4. Fill a cuvette with your weakest solution sample (this would typically be just water).

5. Place the cuvette in the cuvette holder oriented (as illustrated) so that light travels through the cuvette by the shorter path.



6. In the **Data Acquisition** tab of the Configuration screen, set **Integration Time** to 25 ms.

7. Check the spectrum preview in the upper part of the screen; it should not be clipped, especially in the region of 800 nm. If it is, reduce the integration time.

8. Press ⟩ to switch to the **Lamp** tab of the Configuration screen.

9. With the cuvette in place, and the lamp on (you should see light in the cuvette), press F2 (Save Ref).

10. Press ✓ to switch the lamp off.

11. Press F1 (Save Dark).

12. Press ✓ to switch the lamp back on.

13. Press ⟫ to switch to the **Time Acquisition** tab.

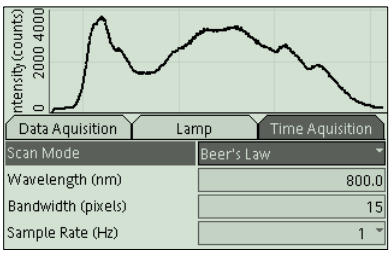
14. Set **Scan Mode** to *Beer's Law.*

15. Set **Wavelength** to 800 nm.

16. Set **Bandwidth** to 15 pixels.

17. Press F4 (Close).

    Result: The Graph screen opens with Absorbance on the vertical axis and Concentration on the horizontal axis.



Beer's Law Set-up

Procedure

1. Press ▶. A flashing icon (⚑) appears in the upper right-hand corner of the screen.

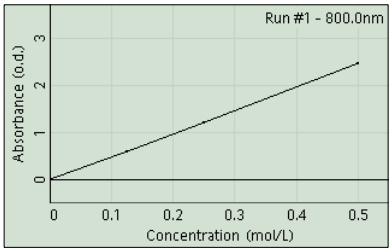
2. Press ⚑. The GLX records a single absorbance value and prompts you to enter a concentration.

3. Type the concentration (in mol/L).

4. Replace the cuvette with one containing the next-higher concentration sample.

5. Repeat steps 2 and 3 for all of your samples.

6. Press ▶ to end the data run.



Beer's Law Data

Analysis

The graph shows a linear relationship between absorbance and concentration in accordance to Beer's Law.

Technical Support

For assistance with any PASCO product, contact PASCO at:

Address: PASCO scientific
10101 Foothills Blvd.
Roseville, CA 95747-7100

Phone: 916-786-3800 (worldwide)
800-772-8700 (U.S.)

Fax: (916) 786-7565

Web: www.pasco.com

Email: support@pasco.com

Limited Warranty
For a description of the product warranty, see the PASCO catalog.